THE IMPORTANCE OF KNOWING THE SIZE OF THE HEART; INACCURACY OF PERCUSSION IN DETERMINING IT AS SHOWN BY X-RAY EXAMINATIONS.

BY
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BOSTON.

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By FRANCIS H. WILLIAMS, M.D.
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Read at the Annual Meeting of the Massachusetts Medical Society,
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THE IMPORTANCE OF KNOWING THE SIZE OF THE HEART; INACCURACY OF PERCUSSION IN DETERMINING IT AS SHOWN BY X-RAY EXAMINATIONS.

In the minds of many, cardiac enlargement is chiefly associated with valvular disease, but there are other causes acting outside the heart which may give rise to an increase in the size of this organ. A murmur is to some pathognomonic of heart disease, but this indication is not to be wholly relied upon, for we may of course have murmurs without organic cardiac disease, and cardiac disease without murmurs.

The *size* of the heart, however, is less open to question as a sign of disease, for if this organ is abnormal in size we have an indication of disease either inside or outside of the heart; on the contrary, if the size is normal it is not probable that any serious chronic lesion of the valves is present.

Let me briefly recall to your minds some of the conditions in which the size of the heart departs from that found in health, since the importance of knowing its size may be best appreciated by considering the conditions under which this occurs. I shall exclude from this category the acute changes in the size of the heart which may accompany excessive exercise, or acute diseases such as pneumonia or acute dilatation of the heart. I desire to lay stress upon the importance of knowing when the heart is smaller than normal, for those persons whose hearts are not so large as the body demands should avoid pursuits and exercises beyond their

strength, and to call attention to the fact that with the usual means of examination a small heart is frequently overlooked.

The chief causes of enlarged heart may be divided into two groups: first, those acting from within the heart wall; second, those from without. In this first group, according to Howard, are valvular lesions, and of less frequent occurrence, fatty heart, tuberculosis and aneurism of the heart.

In the second group, causes originating outside of the heart are in the order of their frequency:

Arterio-sclerosis.
Nephritis.
Pericardial adhesions.
Excessive work.
Alcoholic intemperance.
Tumors (pressing on vascular trunks).

Causes involving enlargement of the right side of the heart are obstructions in the pulmonary circulation, and these are found in various pulmonary diseases, especially emphysema.

The recognition of an enlarged heart may not only warn us of the presence of an otherwise unsuspected valvular lesion, arterio-sclerosis, or chronic nephritis, but if its borders are well determined they may also assist us in recognizing the gravity of the conditions causing the enlargement, and careful determinations of the size of the right and left ventricles may aid us much in prognosis. For example, if we find the left side of the heart only slightly enlarged in arterio-sclerosis it is probable that the disease is not so advanced as if the increase in size were greater, nor is the condition so serious as when the right side has also become involved.

Let us now consider the accuracy with which our present methods enable us to determine the size of the heart, and if this consideration shows that they are uncertain and misleading in a matter of such vital importance, we certainly should not rest satisfied with them if other aids can be obtained.

In a considerable number of cases which I have examined during the past three years, I first determined the borders of the heart by percussion and recorded these outlines on the skin with a blue pencil, and then determined the outline of the heart by an x-ray examination and drew these outlines with a black crayon. On the comparison of these two sets of lines I was much struck by their frequent discrepancy in either one or more borders of the heart, and by the greater completeness of the cardiac outlines as obtained by the x-ray examination.

It then occurred to me to test still further the accuracy of the determination by percussion of the right and left borders of the heart by comparing the *width* of the heart as found in the clinical record with the *weight* of the heart as determined by the post-mortem examination. (It is obvious that this method of comparison may err, for a heart may be so distended during life as to give a large cardiac area to percussion, although it may not weigh much more than normal.) With this end in view I attempted to compare the size of the heart in 1,000 patients as found by percussion and given in the clinical records of the Boston City Hospital, with its weight as found in 1,000 consecutive autopsies. For the use of the autopsy records I desire to thank Dr. Councilman, under whose direction the pathological department of the hospital is conducted.

Four hundred and fifty-four cases were *not* used for the following reasons:

1. The patients were under 20 years of age.
2. No heart weights were given.
3. The records were incomplete.
4. Cases of emphysema, stoutness, etc., in which percussion is at a great disadvantage.

Five hundred and forty-six cases were used.

One thousand, total.

The average weights of hearts as determined by Dr. H. D. Arnold at the Boston City Hospital is 290 grams for men and 253 grams for women. I have divided the 546 cases, (370 men and 176 women, the men and women being classed separately) into six groups each, according to their weights, as will be seen in the following tables, marked *A*.

A

HEART WEIGHTS COMPARED WITH HEART WIDTHS.

MEN. Average weight in health 290 grams.

Group I.—Weights below 225 grams. Nine cases.
7, area normal by percussion.
1, area enlarged by percussion. Small size not recognized in 88%.

Group II.—Weights 225–349 grams. One hundred and sixty-eight cases.
11, area diminished by percussion. Error of 6%.

Group III.—Weights 350–399 grams. Seventy-four cases.
56, area normal by percussion.
6, area diminished by percussion. No enlargement recognized in 83%.

Group IV.—Weights 400–449 grams. Twenty-six cases.
15, area normal by percussion.
1, area diminished by percussion. No enlargement recognized in 61%.

Group V.—Weights 450–499 grams. Twenty-four cases.
9, area normal by percussion. No enlargement recognized in 37%.

Group VI.—Weights 500 grams and over. Sixty-nine cases.
18, area normal by percussion.
1, area diminished by percussion. No enlargement recognized in 27%.

A

HEART WEIGHTS COMPARED WITH HEART WIDTHS.

WOMEN. Average weight in health 253 grams.

Group I.—Weights below 200 grams. Eight cases.
7, area normal by percussion. Small size not recognized in 87%.

Group II.—Weights 200–324 grams. Ninety-nine cases.
*12, area enlarged by percussion.

Group III.—Weights 325–374 grams. Twenty-six cases.
17, area normal by percussion.
1, area diminished by percussion. No enlargement recognized in 69%.

Group IV.—Weights 375–424 grams. Fifteen cases.
5, area normal by percussion.
2, area diminished by percussion. No enlargement recognized in 46%.

*The weights of these twelve hearts were as follows: One weighed 230 grams; two, 245; one, 250; one, 260; one, 270; one, 280; four, 300; one, 315.

Group V.—Weights 425–474 grams. Twelve cases.
4, area normal by percussion.
1, area diminished by percussion. No enlargement recognized in 41%.

Group VI.—Weights 475 grams and over. Sixteen cases.
1, area normal by percussion.
1, area diminished by percussion. No enlargement recognized in 12%.

If you will follow these tables you will see that this comparison between the *weight* of the heart as determined at the autopsy and the *width* of the heart as obtained by percussion shows that:

Group I.—Men.—In nine men with hearts weighing below 225 grams (average weight of normal heart 290 grams) the diminished size was not recognized by percussion in 88% of the cases. The number of cases in this group is small, but in the corresponding Group I. of the women the results are similar.

Group II. In 168 men with hearts varying in weight from 225–349 grams, a variation which I have allowed as normal either side of the 290 grams, 6% were diminished in size by percussion. The weights of those included in this percentage were:

1	weighed	250	grams.
1	"	280	"
2	"	290	"
1	"	300	"
2	"	310	"
1	"	320	"
1	"	325	"
1	"	330	"
1	"	340	"

Group III. In 74 men with hearts weighing from 350–399 grams (average weight of normal heart 290 grams) no enlargement was recognized by percussion in 83% of the cases, and six indeed were even recorded as smaller by this means of examination.

Group IV. In 26 men with hearts weighing from 400–449 grams (average weight of normal heart 290 grams) no enlargement was recognized by percussion in 61% of the cases, and as in the previous group one was diminished.

Group V. In 24 men with hearts weighing from 450–499 grams (average weight of normal heart 290 grams) no enlargement was recognized in 37% of the cases.

Group VI. In 69 men with hearts weighing 500 grams and over (average weight of normal heart 290 grams), no enlargement was recognized by percussion in 27% of the cases and one was recorded as diminished in size by this method.

It is not necessary to go over the table for women, as it is of similar import.

In this comparison I have given the clinical record the benefit of all doubt; for example, I have excluded all cases of emphysema and stoutness.

It is worthy of notice that both these tables show that when the heart is about normal the error made by percussion is least frequent; when smaller than normal, very frequent; when somewhat enlarged, nearly as frequent; as the heart grows larger and larger, the frequency of the error made by percussion decreases, but the amount of error in a given case becomes greater.

Let us now return to Group IV. for a moment. In this group of twenty-six men with hearts weighing from 400–449 grams, no enlargement was found by percussion in sixteen of the cases; in only two of these were there murmurs;* in the remaining ten, which were recognized as enlarged by percussion, four had murmurs.

In Group V., twenty-four men with hearts weighing from 450–499 grams, nine hearts were given as normal by percussion; in only two of these were there murmurs; in the remaining fifteen, which were recognized as enlarged by percussion, eight had murmurs. This may mean that when murmurs are found closer attention is given to the size of the heart.

* At the meeting, tables were presented which showed that in certain of the 546 hearts under discussion murmurs were present both when the valves and weights were normal and abnormal, but these tables need a fuller discussion than the limits of this paper warrant, and I have therefore not printed them.

It is evident from the comparison we have made between the size of the heart as obtained by an autopsy and by percussion that the latter method is inaccurate. Now let us return to x-ray examinations and see how percussion stands as to accuracy when compared with a method which, like percussion, is used during life. (The determination of the right and left borders of the heart was made on a level with the nipples in this comparison.) It is unnecessary to compare the two methods of determining the outlines of the heart as far as completeness goes; the x-ray examination gives much fuller and more detailed outlines.

I will ask your attention to the table marked *B*, which gives the results of this comparison in 107 cases of various diseases. These cases are only a part of those that I have examined with the fluorescent screen, but are those in which I have employed the two methods, *percussion* and *x-ray examination*. The left border in these 107 cases was determined by its distance from the median line in both methods of examination. The figures give the difference in the distance of the left side of the heart from the median line as determined by percussion and x-ray examination in each patient. The plus mark means that percussion made the heart larger than did the x-ray examination, and the minus mark that percussion made the heart smaller.

The table consists of four double columns; in the first column, thirty-one cases, in one-third of which the hearts were larger than normal, the difference between the left border as determined by percussion and x-ray examination was less than one centimetre. This we will call agreement.

In the second column, thirty-seven cases, in one-half of which the hearts were larger than normal, the difference was one centimetre or more, and less than two.

In the third column, twenty-five cases, in one half of which the hearts were larger than normal, the difference was more than two centimetres and less than three.

In the fourth column, fourteen cases, in one-half of which the hearts were larger than normal, the difference was more than three centimetres.

The table also shows whether the disagreement between the two methods was more often plus or minus in the 107 cases. If we deduct from the total number the thirty-one cases, in which I have called the results of the two alike, we have left seventy-six cases. By percussion thirty-nine of these were larger and thirty-seven were smaller than by an x-ray examination.

In the cases in the left hand side of each double column the total width of the heart by an x-ray examination was thirteen centimetres or less; in those in the right hand side it was over thirteen centimetres. (The average width of the heart in health as determined by an x-ray examination in forty-eight men was, from the median line to right border, 3 cm., to left border 8.6 cm., total 11.6 cm.; in thirty-one women the right border was 2.5 cm., left border 8.7 cm., total 11.2 cm. These cases indicate that the heart in women lies a little more to the left than in men.) Thus it will be seen that in cardiac disease the error made by percussion was more frequent among the larger hearts than among those of nearly normal size.

It should be stated that I have taken pains, from time to time, to get other physicians to determine by percussion the size of the heart in some cases, and I then compared it with that obtained by an x-ray examination; as yet I have found no one whose percussion like mine in the same cases did not give the size of the heart incorrectly when tested by an x-ray examination.

If we consider the table (B) in a general way and look at the groups of diseases, it seems that percussion is very likely to err in finding the position of the left border of the heart when it is of the most importance to have accurate information about this organ, namely, in cardiac disease

B

DIFFERENCE OF X-RAY AND PERCUSSION DETERMINATIONS OF LEFT HEART BORDER IN 107 CASES.*

LESS THAN 1 CM.	1–2 CM.	2–3 CM.	3 CM. AND OVER.
Aneurism.	*Aneurism.*	*Aneurism.*	*Aneurism.*
0	+1.75	+2.50 +2.00	+3.00 —4.50
0		+2.00	
			New Growth.
	Bronchitis.	*Bronchitis.*	—4.25
	—1.00	+2.00	
	+1.50		
Cardiac.	*Cardiac.*	*Cardiac.*	*Cardiac.*
0 +.50	+1.00 —1.00	—2.00 +2.00	—3.00
0	—1.00 +1.00	+2.50 —2.00	+3.00
0	+1.25 —1.00	+2.50 —2.00	+4.00
0	—1.50 —1.00	+2.75 —2.00	
0	+1.75 +1.00	—2.25	
	+1.75 —1.25	—2.50	
	—1.50	—2.50	
	—1.50	—2.50	
	—1.75		
	Nephritis.		
	+1.00		
Anæmia.		*Anæmia.*	
+.25		—2.00	
+.75			
0			
Rheumatism.	*Rheumatism.*	*Rheumatism.*	
—.50	+1.25 +1.50	—2.25	
+.75	+1.75		
Pleurisy.	*Pleurisy.*		
+.50	—1.75 —1.00		
	—1.00		
Tuberculosis.	*Tuberculosis.*	*Tuberculosis.*	*Tuberculosis.*
0 —.50	+1.00 +1.50	+2.00 +2.50	+3.00 +3.50
+.25	+1.00 —1.75	—2.00	—3.25 —4.25
—.25	+1.25	+2.50	+4.00
+.50	—1.25		—4.00
—.50			
—.50			
—.75			
—.75			
Pneumonia.	*Pneumonia.*	*Pneumonia.*	*Pneumonia.*
0 —.25	+1.00 +1.75	—2.50	—4.00
—.25 —.25	—1.00 +1.75		
—.25 —.50	—1.50		
Typhoid Fever	*Typhoid Fever.*		
—.50	+1.25		*Pericardial Adhes.*
			—4.75
Tape Worm.		*Emphysema.*	
—.50		+2.25	
		Malaria.	
		+2.00	
Total, 31	Total, 37	Total, 25	Total, 14

* + Means percussion made the heart larger than the x-ray examination.
— Means percussion made the heart smaller than the x-ray examination.
The left hand column in each of the four double columns contains the cases where the heart's width was 13 cm. or less; the right side those in which it was over 13 cm.

when the heart is enlarged. Percussion also errs when the heart is displaced. To illustrate the advantage of an x-ray examination in this latter case, let me refer briefly to a patient who consulted me recently for supposed cardiac disease. The left border of the heart, as well as the apex beat, was outside of the nipple line; the right border was not easily defined, but seemed to be in about the usual place. Without an x-ray examination I should have considered that he had an enlarged heart; this examination showed, however, that the heart was not enlarged but was simply drawn to the left. Upon inquiry I found that he had had a left-sided pneumonia forty years before. When the heart is pushed out of place by fluid or a tumor in one or both sides of the chest or in the abdomen, the displacement as a rule is much more certainly recognized by an x-ray examination than by other means.

In the few cases in which I have had an opportunity to compare the size and position of the heart, as shown by an x-ray examination, with that found at autopsies, they have all agreed; except that after death the heart was somewhat higher than in life.

When the heart is normal in size, its border, so far as it can be obtained by percussion, can usually be obtained correctly; when it is of abnormal size, whether smaller or greater, this condition may not be indicated by percussion.

If by an x-ray examination we find in any patient (excluding acute diseases) an enlarged heart we should consider the probability of valvular lesions, arterio-sclerosis (especially in middle age and after), renal disease and emphysema (this last condition of the lungs would be very obvious by an x-ray examination).

If we find the heart normal in size and no history of disease standing in causal relation to valvular trouble, we probably have not to do with a serious chronic condition of the heart even though some murmurs are present.

Fig. 1, A.

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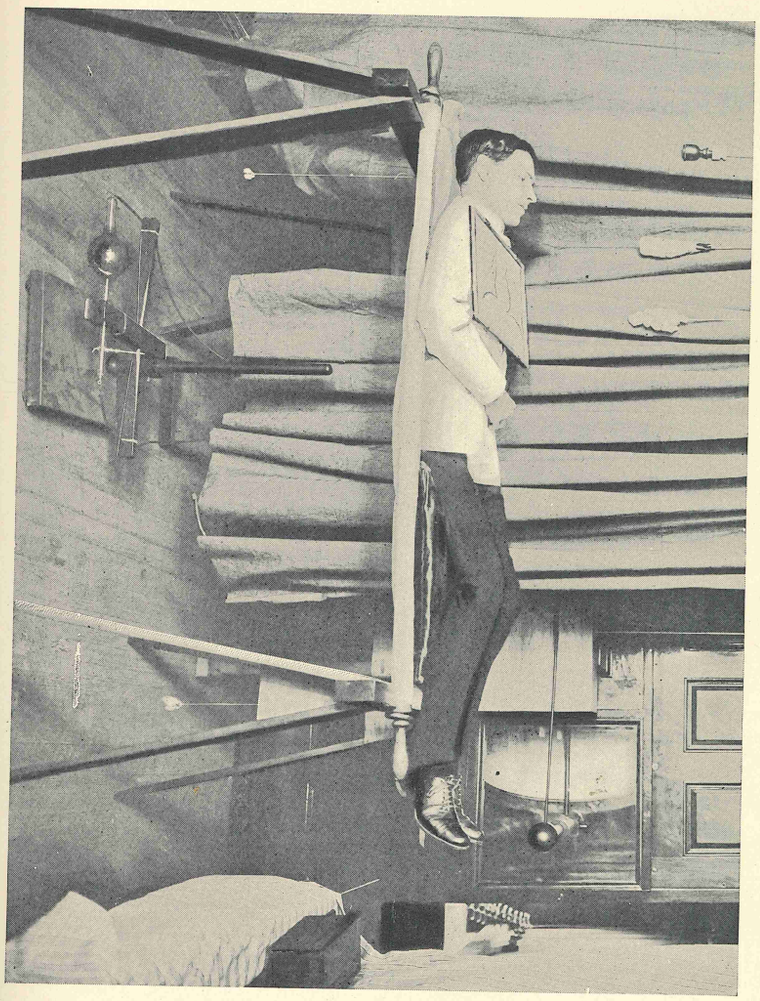

Fig. 1, A.

Small hearts may be recognized by an x-ray examination.

An x-ray examination, when the lungs are clear,* enables us to distinguish the outlines of the ventricles more exactly than percussion; a displaced heart is not mistaken for an enlarged one; the direction of the long axis can be obtained; if the heart is abnormal in size we can ascertain whether the right or the left or both ventricles are enlarged; the enlargement of the auricles can be distinguished.

In a word the size of the heart can be determined more accurately and more certainly by x-ray examinations than by our former methods; these examinations are of especial value in the early stages of cardiac enlargement as then so much more can be done for the patient than when the enlargement has made great progress.

Fig. 1, A. This cut shows my method of making x-ray examinations of the thorax. The patient is lying on a stretcher and the anode of the vacuum tube is under the point where the median line is crossed by a line joining the nipples and three or four feet from it. The fluorescent screen (covered with a transparent film on which the cardiac outlines have been drawn) lies on the patient's chest. One of the cords over the patient's head is used to turn the electric current on or off; the two others are used to increase or diminish the light as may be desired while the examination is being made. The aluminium screen, which is always placed between the Crookes tube and the patient, has been taken away in order to show the position of the tube. The curtain is drawn aside at the foot of the stretcher in order to show

* Unless the thorax is too opaque to the x-rays from disease we see a portion of the left border of the heart clearly defined during quiet breathing; we do not, however, always see the right border at this time. During a deep inspiration the whole of the left border of the heart is clearly seen and the right border also comes into view. The width of the heart can therefore be best obtained during deep inspiration, as then both borders are seen together; but there may be an error in some cases in this determination on account of the heart's being compressed by the lungs. In cases where the heart is enlarged so that both borders may be seen at the same time during quiet breathing, its width may then be determined; the diminution in width during full inspiration as compared with quiet breathing may sometimes aid us in distinguishing a heart that is dilated from one that is hypertrophied.

the end of the case which encloses the static machine. This machine has four revolving plates six feet in diameter, and four fixed plates six feet four inches in diameter and adjustments requisite for examinations of the thorax. (See Fig. 1, B.)

If the heart is enlarged each border may be determined separately by the aid of an indirect plumb line which I devised for this purpose.*

I desire to express again my obligation to Dr. William H. Rollins of Boston, not only for the advances which have resulted from his studies of vacuum tubes, by which I have been greatly aided, but also for his constant helpfulness in furthering my work.

EXPLANATION OF HEART OUTLINES.

Figures 2–7 inclusive are photographic reproductions two-thirds the size of the original tracings made on the chest wall to show the position of the heart's border as determined by percussion (broken lines) and by x-ray examination (full lines).

In Fig. 2, John W. M., the x-ray line of the left border of the heart was outside of the percussion line.

In Fig. 3, Catherine P., the position of the left border of the heart as determined by the x-ray examination was inside of the line as indicated by percussion.

In Fig. 4, Mary F. D., the right chest contained fluid which pushed the heart to the left; this displacement was not recognized by percussion. It may be that displacements are sometimes not readily recognized by percussion, because the heart is pushed into the body of the lung rather than along or near the chest wall.

Fig. 5. Mary M. This was an unusual case. There was fluid in the left chest which displaced the heart to the right, but as she had also at the same time pneumonia in the lower part of the right lung the heart was not pushed directly to the right, but was forced upwards. Hence the right border of the heart was found to the right and above a line joining the sternal notch and the right nipple.

* Amer. Jour. Med. Sciences, June, 1899, p. 688.

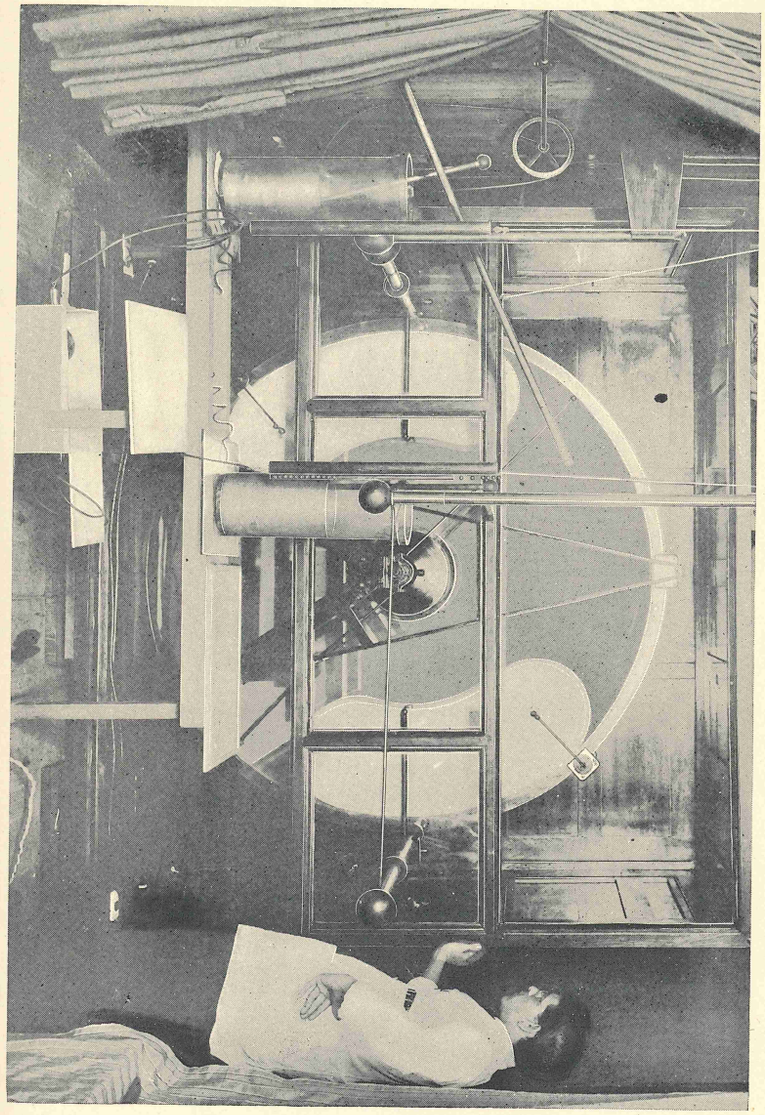

Fig. 1, B.

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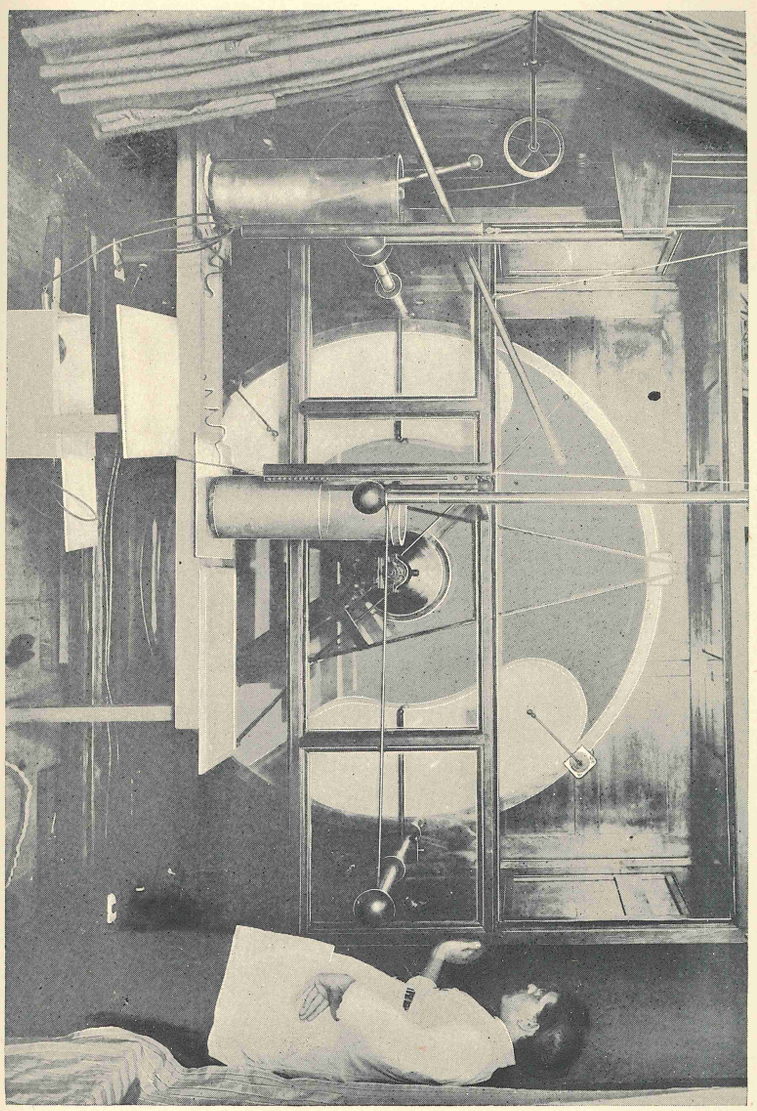


Fig. 1, B.

Fig. 2.

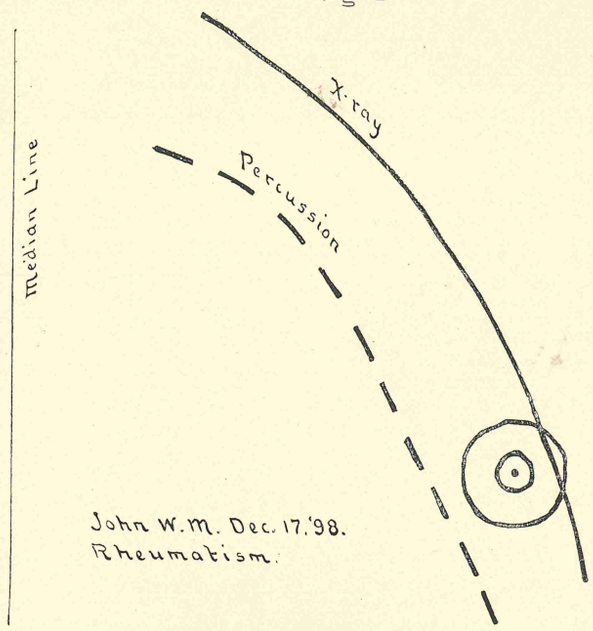

Median Line
X-ray
Percussion
John W.M. Dec. 17.'98.
Rheumatism.

Fig. 3.

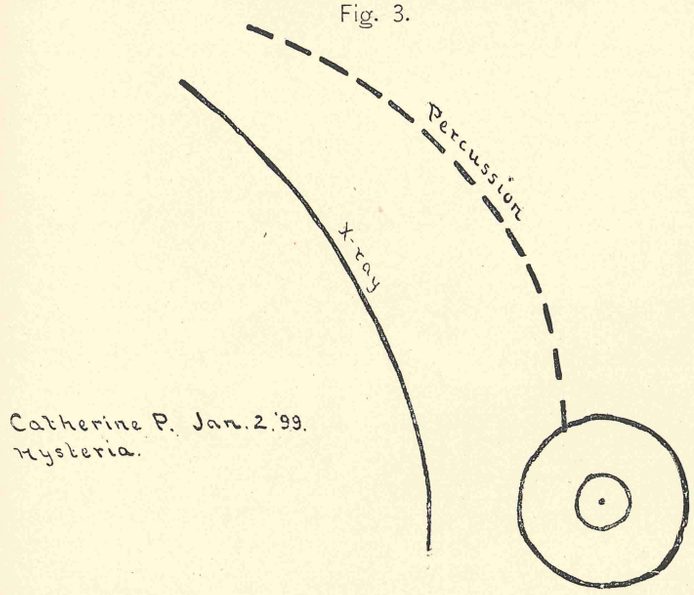
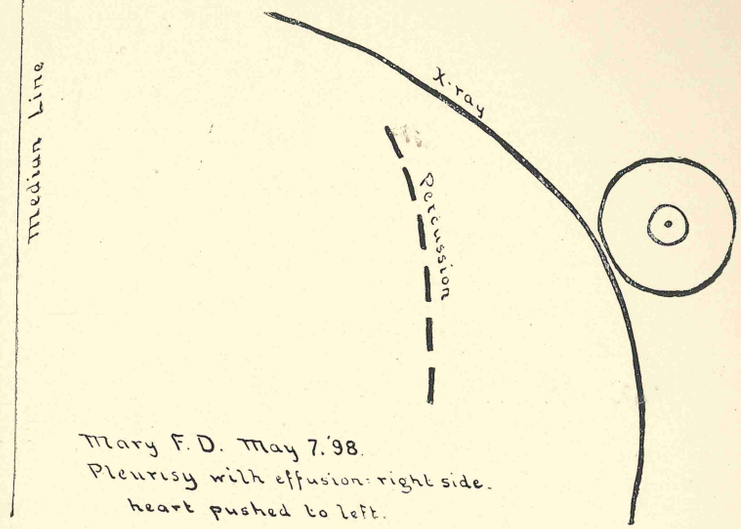
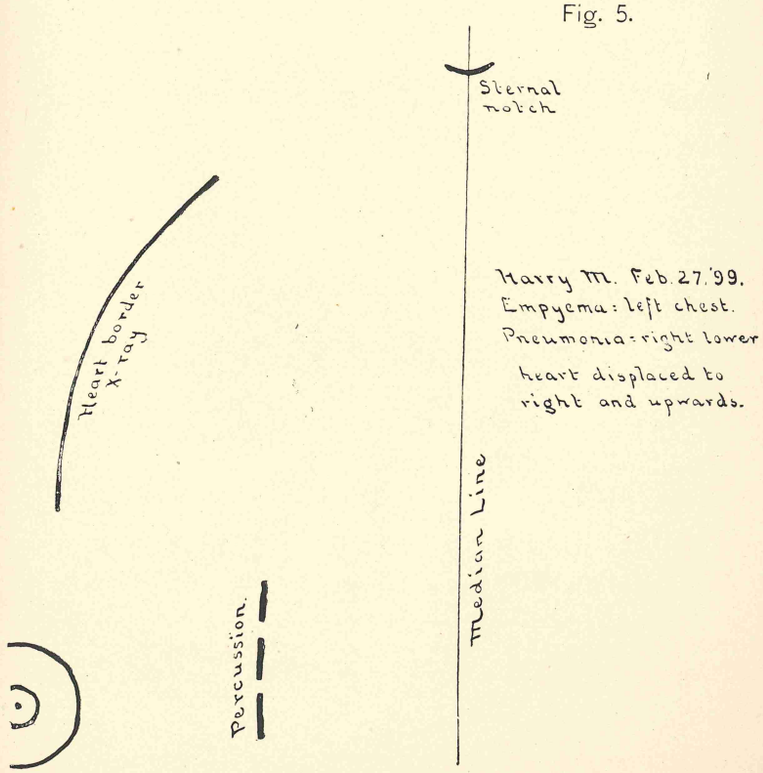

Percussion
X-ray
Catherine P. Jan. 2.'99.
Hysteria.

Fig. 4.



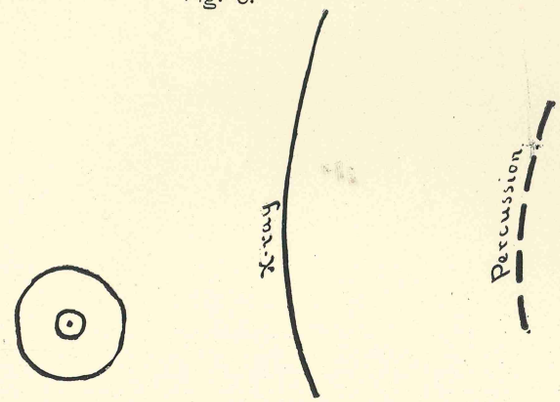
Mary F. D. May 7. '98.
Pleurisy with effusion: right side.
heart pushed to left.

Fig. 5.



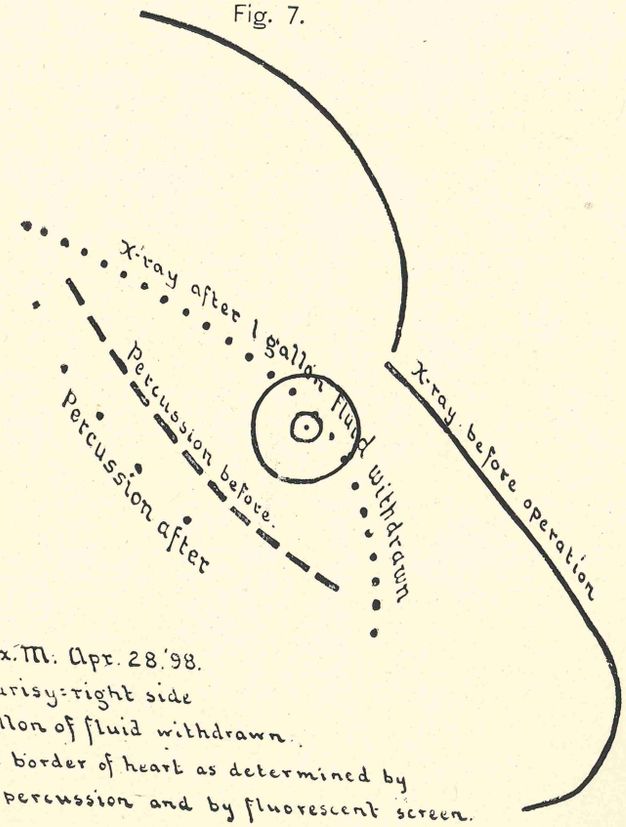
Harry M. Feb. 27. '99.
Empyema: left chest.
Pneumonia: right lower
heart displaced to
right and upwards.

Fig. 6.



Constantin D. Jan. 23, '99.
Pleurisy with effusion left side:
heart pushed to right.

Fig. 7.



Alex. M. Apr. 28. '98.
Pleurisy: right side
1 gallon of fluid withdrawn.
Left border of heart as determined by
percussion and by fluorescent screen.

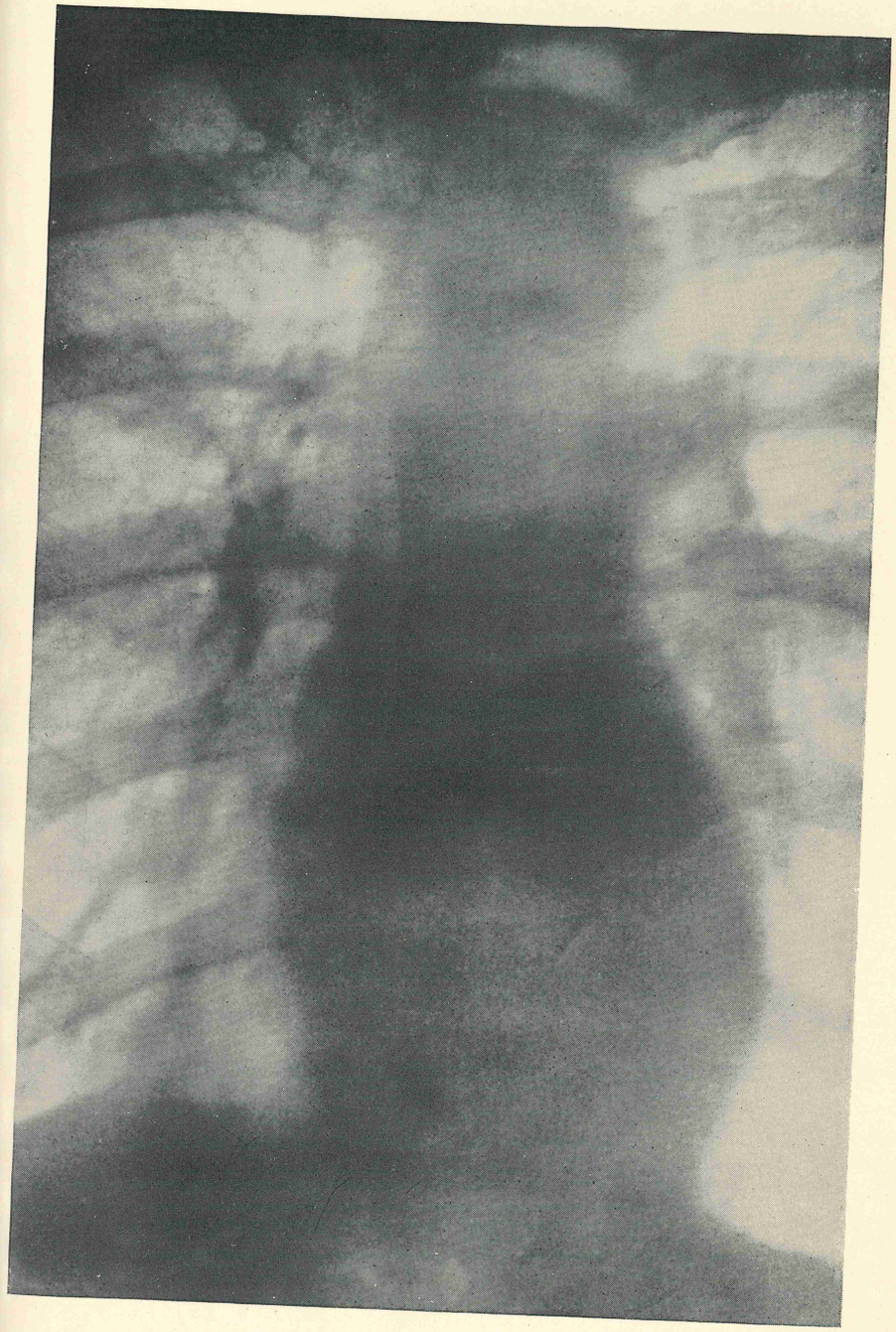


Fig. 8.

Fig. 6. Constantin D., shows the right nipple and the right border of the heart pushed towards it by fluid in the left chest. In this patient percussion did not recognize the right border of the heart within an inch and seven-eighths.

Fig. 7. Alex. M. had a very large pleuritic effusion in the right side which pushed the heart far to the left and much outside the left nipple. The position of the left border of the heart before the fluid was withdrawn is shown by the full line, after its withdrawal by the dotted line crossing the nipple. The position of the same border as determined by percussion before the operation is shown by the broken line, after operation by the dotted line below it.

During quiet breathing only a portion of the heart's border is visible by an x-ray examination, but as I pointed out in 1896, the patient should take a full breath when we wish to see the outlines of the heart more fully. Thus far I believe the heart has never been photographed between the respirations and during full inspiration. Figure 8 is a reproduction of an x-ray photograph of the heart taken under these conditions. It is about one half the original size and shows, above the fourth ribs, the outer border of the superior vena cava and of the aorta, below the fourth ribs, the heart; the diaphragm is seen at the bottom of the picture.

In the photographic process of reproducing the x-ray photograph of the heart, the clearness of the original is lost; the pulsations of the heart also diminish the sharpness of its outlines. The dark areas in each side of the heart, which have in general a direction downward and outward, are the shadows of the pulmonary vessels. In the original negative there is seen on the right side, above the heart, the outline of the outer side of the superior vena cava, and within it, that of the ascending aorta. The curve of the descending aorta may be easily followed in the negative, but is lost in the half tone; in the original nearly the whole of the outer curve of the ascending, transverse and descending arches of the aorta may be followed.